Breath Time: Breathing Exercise Product through Physical Volumetric Change

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Abstract

Breathing is always a necessary part of people. However, the term "breathing method" is not commonly used, and it is widely used only in a specific field. Yoga offers a variety of breathing methods, alternative medicine also suggests breathing method. There are papers that can be used to lower stress using deep breathing. Despite these advantages of breathing, apps that encourage people to breathe easily are not able to draw deep involvement of people. I tried to design for stressed students or stationery workers as target users and fit them into their living environment desks. In this paper, I propose a breathing product, Breath Time, and investigate its breathing exercise effect compared to apps.

The breathing time is a product that changes volume to 3d by moving out of the current solution, 2d display environment. To express the volumetric change, I used hoverman sphere mechanism composed of frames. It was designed to be an on-desk product to be placed on desk for my target user considering their context. As an breathing exercise product, it has several modes right now, for relax, for sleep and using pranayama breathing method. These three methods are commonly used in the breathing field. They have different inhaling, exhaling and holding time.

In this study, I compared brething data got from apps and product each. After checking the breathing pattern, interview was conducted to get the thoughts on the product. Six breathing graph is got from each participants for comparing three different breathing methods. To analyze the data, normalization was used to compare the breathing graph waveform. To quantify similarity of two graph, Pearson correlation coefficient was used. Interview was conducted to gather the difference of breathing between product and apps.

Through the experiment, I identified that the breathing exercise effect of product was similar to apps. But, in aspect of breathing itself, both apps and product had a main problem on breathing that it was hard to following exactly as breathing instruction. Due to reaction time and personal breathing ability, this phenomenon occurred. New type of system should be suggested and this will be metion in the discussion. Interview data was also collected and analyzed and the I glanced the potial using as an on-desk product. People mentioned this mechanism make people feel mindfulness.

Contents

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Introduction

Background

Stress and mental wellness

Stress is a significant factor having influence both physical health and mental health. Stress can not only have an effect on disease like cardiovascular disease (CVD), human immunodeficiency virus (HIV)/AIDS but also depression(Cohen et al, 2007), loneliness and lethargy concerned with mental illness. These influences productivity of people and can cause social loss. Due to lost productivity, absenteeism, poor decision making, stress-related metal illness, and other effects caused by stress in employees, $150 billion loss occurs annually in the U.S.(M. Kalia, 2002). The National Institute of Occupational Safety Health found that approximately 40% of working adults feel extremely stress in their workplace.(DHHS (NIOSH), 1999) Not only the worker, students are prone to the stress. (David Robotham, 2008) These indicate that managing stress and caring the mental wellness is necessary.

Not only the trial manage stress, there are trials to have people mindfulness in aspect of mental wellness. Including meditation, people want to feel fullness in their mind to fully focus on themselves or get rid of concerns or borders that impede themselves. Meditation effect have a large boundary such as greater well-being, the ability to concentrate better, stress release, or developing higher mental states.(Eberth, 2012*)* Also, people`s interest in meditation increased for more mental well-being through the number of papers published in 2012 is 477 compared to 52 published in 2003.(Pickert K, 2014)

Breathing techniques

Breathing techniques are widely used in meditation field. It is noted that breathing is basic of meditation. In Anapanasati, buddhist meditation form, breathing technique is not establish in terms of time, breathing volume but breathing is watched by meditator. Meditator do meditation while notice whether the breath is long or short. There are many breathing techniques not written in words, or not standardized. But there are several breathing methods that help people do meditate, in other words relax, stress relief, better sleep and medical treatment. Deep breathing, not standardized in seconds but in the volume, that have people inhale maximum and exhale maximum, have a stress relief effect. (Paul et al, 2007) 478 breathing technique is well know method for sleeping introduced by Dr. Weil who is celebrated in the alternative medicine and integrative medicine field. By Dr. Weil this technique can make people relax and have a sleep. Pranayama breathing, yogaic breathing, is not also defined but has a basic rule. Inhale to maximum, and hold, exhale to maximum, and hold is the basic cycle of the method. Normally, it is recommended for novice for 5 second of exhale and inhale, and

4~8 second to hold. In this research, paranayama and yoga has an impact on stress, anxiety, cancer, diabetes mellitus and etc.(Sengupta et al, 2012)

Solution Limitation

Most of the suggested solutions are in the form of APP and provide information through 2d(figure 1).

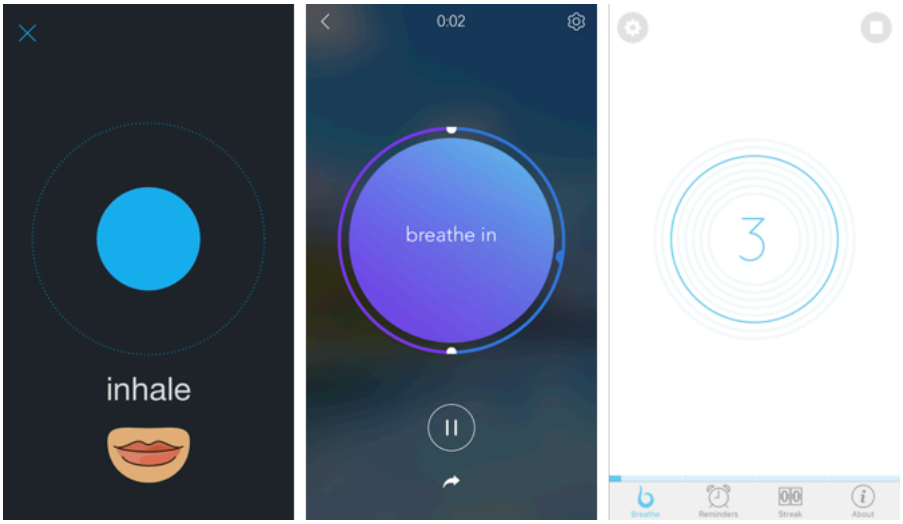


figure 1. Three applications inducing deep breathing. From the left, 'Breath Deep', 'Calm' and 'breath 478'

MARS, Mobile application Rating Scale,(Mani et al, 2015) rating on meditation application, I focused on engagement level and PB(Program Based) practice. In these table, engagement is not high scored compared to other factors. Among those 25 applications I could find out, only 5 could give the PB practice and among 5 only 3 gives breathing exercise.(figure 2). Researchers found that aesthetically pleasing and well designed apps make people engage more than other cases.(Cyr D et al, 2006, Maghnati F et al, 2013)

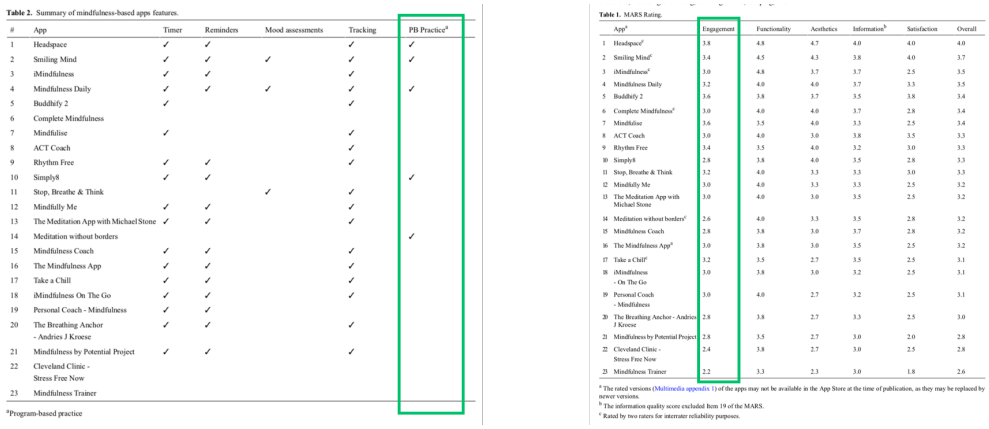


Table 2. Summary of mindfulness-based apps features.

#	App	Timer	Reminders	Mood assessments	Tracking	PB Practice[a]
1	Headspace	✓	✓		✓	✓
2	Smiling Mind	✓	✓	✓	✓	✓
3	iMindfulness	✓	✓		✓	
4	Mindfulness Daily	✓	✓	✓	✓	✓
5	Buddhify 2	✓			✓	
6	Complete Mindfulness					
7	Mindfulise	✓			✓	
8	ACT Coach				✓	
9	Rhythm Free	✓	✓		✓	
10	Simply8	✓	✓			✓
11	Stop, Breathe & Think			✓	✓	
12	Mindfully Me	✓	✓		✓	
13	The Meditation App with Michael Stone	✓	✓		✓	
14	Meditation without borders					✓
15	Mindfulness Coach	✓	✓		✓	
16	The Mindfulness App	✓	✓		✓	
17	Take a Chill	✓	✓		✓	
18	iMindfulness On The Go	✓	✓		✓	
19	Personal Coach - Mindfulness	✓	✓			
20	The Breathing Anchor - Andries J Kroese	✓	✓		✓	
21	Mindfulness by Potential Project	✓	✓		✓	
22	Cleveland Clinic - Stress Free Now					
23	Mindfulness Trainer					

[a]Program-based practice

Table 1. MARS Rating.

	App[a]	Engagement	Functionality	Aesthetics	Information[b]	Satisfaction	Overall
1	Headspace[c]	3.8	4.8	4.7	4.0	4.0	4.0
2	Smiling Mind[c]	3.4	4.5	4.3	3.8	4.0	3.7
3	iMindfulness[c]	3.0	4.8	3.7	3.7	2.5	3.5
4	Mindfulness Daily	3.2	4.0	4.0	3.7	3.3	3.5
5	Buddhify 2	3.6	3.8	3.7	3.5	3.8	3.4
6	Complete Mindfulness[c]	3.0	4.0	4.0	3.7	2.8	3.4
7	Mindfulise	3.6	3.5	4.0	3.3	2.5	3.4
8	ACT Coach	3.0	4.0	3.0	3.8	3.5	3.3
9	Rhythm Free	3.4	3.5	4.0	3.2	3.0	3.3
10	Simply8	2.8	3.8	4.0	3.5	2.8	3.3
11	Stop, Breathe & Think	3.2	4.0	3.3	3.3	3.0	3.3
12	Mindfully Me	3.0	4.0	3.3	3.3	2.5	3.2
13	The Meditation App with Michael Stone	3.0	4.0	3.0	3.5	2.5	3.2
14	Meditation without borders[c]	2.6	4.0	3.3	3.5	2.8	3.2
15	Mindfulness Coach	2.8	3.8	3.0	3.7	2.8	3.2
16	The Mindfulness App[c]	3.0	3.8	3.0	3.5	2.5	3.2
17	Take a Chill[c]	3.2	3.5	2.7	3.5	2.5	3.1
18	iMindfulness - On The Go	3.0	3.8	3.0	3.2	2.5	3.1
19	Personal Coach - Mindfulness	3.0	4.0	2.7	3.2	2.5	3.1
20	The Breathing Anchor - Andries J Kroese	2.8	3.8	2.7	3.3	2.5	3.0
21	Mindfulness by Potential Project	2.8	3.5	2.7	3.0	2.0	2.8
22	Cleveland Clinic - Stress Free Now	2.4	3.8	2.7	3.0	2.5	2.8
23	Mindfulness Trainer	2.2	3.3	2.3	3.0	1.8	2.6

[a] The rated versions (Multimedia appendix 1) of the apps may not be available in the App Store at the time of publication, as they may be replaced by newer versions.
[b] The information quality score excluded Item 19 of the MARS.
[c] Rated by two raters for interrater reliability purposes.

figure 2. MARS and Table from Mobile application evaluation paper. Left side is feature, Right is MARS Rating

"GUIs fall short of embracing the richness of human senses and skills people have developed through a lifetime of interaction with the physical world." Ishii Hiroshi mentioned.(Ishii, 1997) At this point, I recognized the limitation of 2D display and tried to convert the solution to 3d for more engagement. Based on the effects of previous breathing and the link between Mindfulness, I wanted to create a product that helps physical health as well as mental health through breathing technologies now being used.

Design and Research Aim

Design aim

Breathing through 2D display has a limitation of engagement. Through the 3D physical interaction, designing the breath exercise product for stress relief is aim of this design project. I set my target user as students and stationery workers who are vulnerable to stress. Thinking of their context, it is proper designing the product that can be used on their desk at daily life for more engagement.

Research aim

Evaluation on the effect of Breath time, designed for 3D interaction, is the aim of this study. Through the intermediate prototype, I tried to find the design requirements and findings through the experiment. These requirements got from the study would be applied to next version of prototype. Basic research questions are (1)3D volumetric will have similar inducing power compared to 2D display, (2)Breathtime has people engage more than 2D display, (3)Breathtime is helpful to relieve stress.

In this study, evaluation on the effect of Breathtime whether this product could give people deep breathing was conducted. Through this intermediate prototype, I can apply the findings to next experiment of evaluation on the engagement.

Process

Research driven design Project

Other than the research through design approach, I chose the research driven design project. The RTD(research through design) is one way of design research to prove their hypothesis through design prototype or outcome. But in this study, I did a research to prove or to evaluate for achieving the design goal. This process is, in short, to get to the design goal, that I have to convince or prove the doubt cause during the process of design.(figure 3)

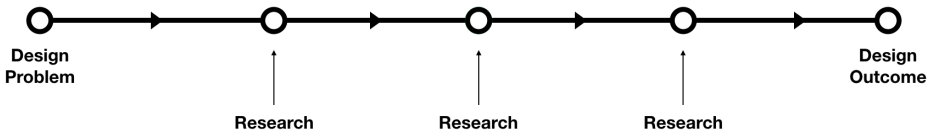


figure 3. Research driven Design Project

To reach to final design outcome, the problems I encounter should be proven. At that point, research is conducted to prove or to figure out findings. After research, findings will be applied to next version of prototype to solve other design problem. Iteration of this process, final design outcome will be obtained through this process.

Literature Review

Inducing Deep Breathing

Hold my breath and breath with me

Currently, through tactile, an attempt has been made to reflect the user's heart rate. The product attempted to drive the Meditation by providing touch to the human hand through a haptic response from the Tangible Interface. In this paper, the author argued that user groups with special needs, such as children, inmates, (cancer) patients, or crime victims, may benefit from tangibles most, convincing and helping them in establishing trust towards healthy meditation practices. (Aslan et al, 2016) (figure 3)

figure 4. Left side is design implementation and early design and Right one is covered with fabric through insight found from the research work

Breathing friend

Similar cases exist. In this paper, the product was produced and tested, and the product was made to be graspable, and the volume change of the product was felt by hand to induce breathing techniques. The experiment was conducted to assess usability of diary studies, interview with teraphists, and preloading ordersncy. As such, Tactile interaction has been attempted in breathing and has validated its effectiveness. (Macik et al, 2017) (figure 5)

figure 5. Breathing friend exterial design. From the left was form seeking, form design and final exterior design

ExoBuilding

The way to utilize it as a building rather than a product has also been suggested. This is a study which tried to see the reaction by changing the light and volume by receiving three kinds of bio-signals.(figure 6) Some of these experiments were said to be relaxed, and the rest stated that there were contrary responses.(Schnädelbach et al, 2012)

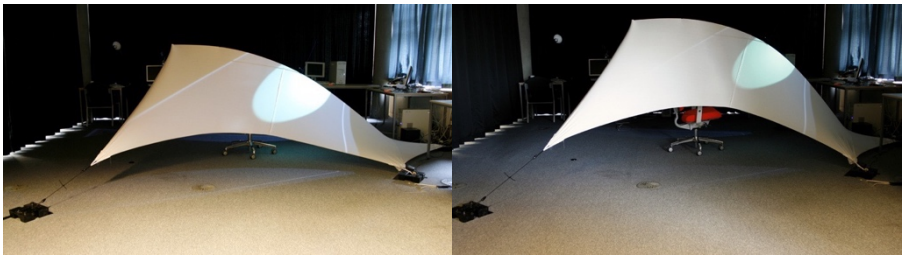


figure 6. Exbuilding, Left is exhaled position, Right is inhaled position.

Depending on the person's breathing, the volume of the tent shape changed, providing a heartbeat sound along the heartbeat, changing the light, and changing the graphic that maps to the tent shape according to EDA.

Breath Coach: A Smart In-home Breathing Training System with Bio-Feedback via VR Game

Attempts to assist in breathing in virtual reality are continuing, except for practical products and tangible ones. One example is the introduction of gamification as shown below. (figure 7)As shown in the figure, I provide a graph or make it follow the balloon, or the plane's pilot, and provide it in a way that reaches the goal quickly.(Tu et al, 2018)

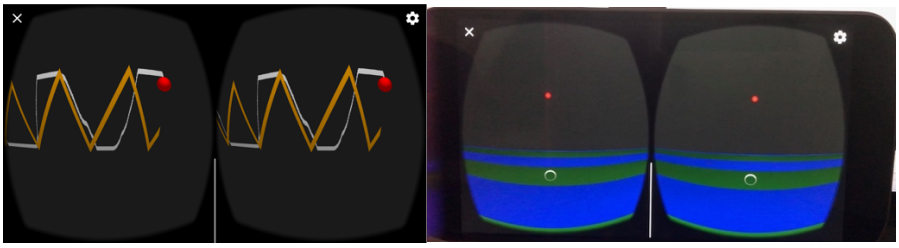


figure 7. Breath Coach. VR Games for breathing. Left is graph following, Right is being a pilot.

Researchers saw the possibility of VR games and bio feedback at home through this product. As an VR trial on the breathing experience, it could be explained more to 3d world, but has a limitation of graphics likewise 2d display.

There have been attempts to move the product through biofeedback, or to draw it into the virtual reality using biofeedback for respiration training. However, no attempt was made to move 2D graphics to 3d. If the mental modality of the respiration of the people was area change in 2d, it would be a volume change in 3d.

Shape Chage Effect

BreathingFrame

There was a study that experimented to make a frame that looks like breathing for a family far away. Measure the respiration of another person and blow the air into the product in which the measured data is in frame form to change the volume. In this study, researchers tried to test the value of the frame. (figure 8)One of the finding was when volumetric change is in stabilization, participants mimic the frame volumetric change. It means that they follow the other person`s respiration through a volumetric change. (Kim et al, 2015)

figure 8. BreathFrame Design, Inflatable design

I focused on the finding that volume change effect on breathing. I thought that it was possible to induce breathing training to people through this volume change as well as various volume changes. Based on this, I need a consideration about how to change the volume.

LOOP

In the research, researchers tried to visualize the activity data, in an alternative way. (figure 9) They suggest new way of activity data physicalization as a physical object(Sauvé, K et al. 2017).

figure 9. Loop Design

They used a Fibit to gather the activity data like movement distance, the amount of calories consumption and other various exercise data. The rotation angle is their way of data visualization that can be seen as an area. Depending on the angle of view, this can be seen as volumetric. This interaction based on ring shaped frame, could be applied to volumetric change. In this paper, they did not mention about their finding due to demonstration format.

Summary

In this section, I could find several trials on deep breathing experience, through tactile and visual gamification. But physically demonstrated product could not be seen. Using biofeedback data, this tangible interaction could be interpreted as inducing deep breathing, but the programmed deep breathing is not suggested yet. 2D applications are existing not suitable for users` context. Through volumetric change, making people breath is possible. Design composed of frame is not proven for the breathing instruction. In this point, I can design product that can give breathing instruction or make people breathing through movement for students or stationery workers.

Breath Time: Development of product

Design of Breath Time

Based on the previous process, the design was revised. The necessary parts of the above process are:

1. visually aesthetic
2. volumetric change in all direction
3. minimum mechanical elements

and additional factors are existing through limitation of last prototype:

4. Mechanism change
5. Sound
6. Input Button

These are the new design requirement of our design. Our major part of new design is mechanism change and visually aesthetic. From the previous mechanism, pushing and pull using linear servo motor, I changed to high torque servo motor using the mechanism of pulley for pulling the wire to expand. I have to consider that product should be match with the desk environment.

figure 10. Rendered image of final Design, Breathtime

From the button, vision is concentrated in to the center and as using a C-shape pipe, hoberman sphere is limited in that area. (figure 10) The ends of the C pipe, the gold metal is a point of the design. And putting the jog dial in front of the body, I can have people change the method of breathing easily.

Using scenario of product

There are two main usage existing in aspect of product. One is working similarly as application suggested. From the start button to the breathing exercise instruction, this process will help people who wants the breathing exercise in their space to relax or take a rest time. The last one is the product working as breathing inducer like mindfulness product. In this using scenario, people will work or do

other things while the product is on. This kind of volumetric movement will induce people to do breathing following the movement. In this study, we adopted the first scenario for instruction product as application in design study and for further usage potential, I generated the experiment for watching the potential as an on-desk product in discussion section.

Mechanism and motor test

Based on the force and mechanism of previous one, i tried to find out the minimum value of torque to make it work. And for precise controlling the volume, using servo motor was suitable for the mechanism.

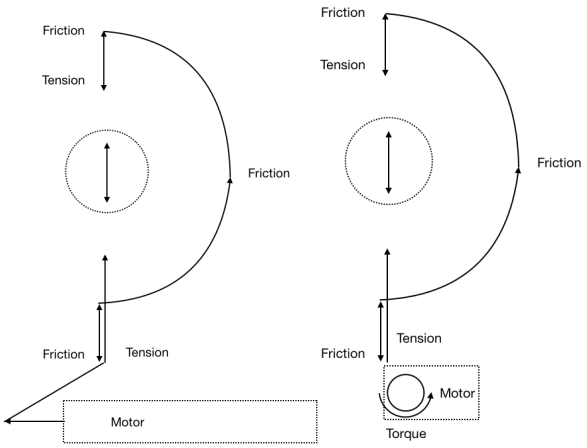


figure 11. Free body diagram of prior mechanism and final mechanism

After drawing the FBD(Free body diagram), I could not find the actual value of tension or other friction due to lack of information on the material or tension itself. Previous motor power was 30N, and it was enough to generate whole system, so wire tension on the motor side was 28.1N. It means that if I use 1.7cm pulley, radius, then motor torque should be about 48N.cm so that I can easily generate. For under the torque 10N.cm, motor stopped, and for almost 29N.cm is loaded the mechanism is going to work when the pulley size was 2cm radius. So in case of 1.7cm, 24.65N.cm should be minimum for design.

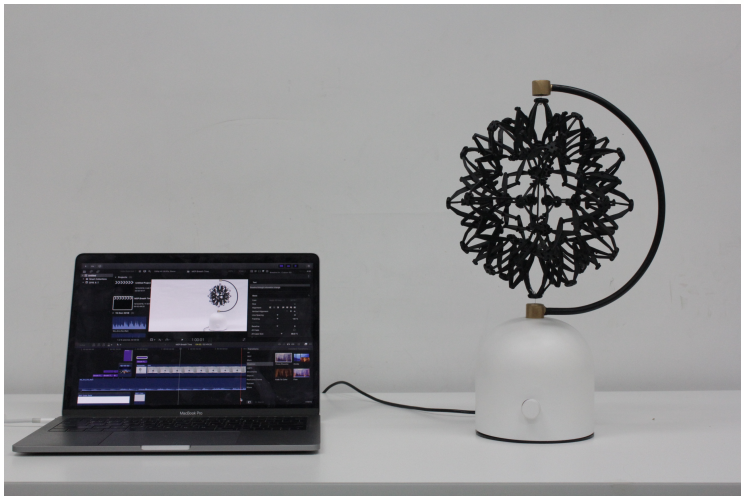


figure 12. The design of Breath-Time.

Implementation

Hardware

There are 7 components except the arduino board. Main body, C shape pipe, hoberman sphere, motor, potential meter, motor bracket and jog dial cover. In this design, main body is holding all the component in side. Main body is made by EDEN(3D printing). To make the feel of ceramic, it is painted with matte white. It has three fixing parts, motor, potential meter fixing and C shape pipe. Main body feature is under below. (figure 13)

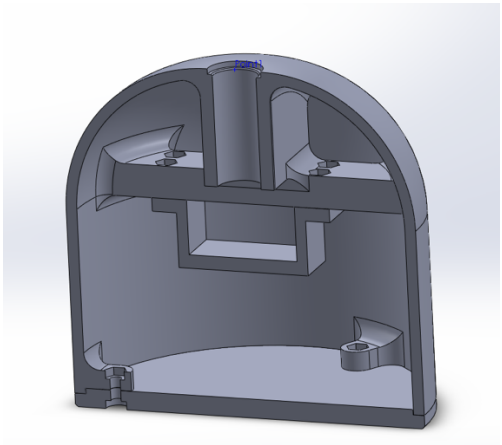


figure 13. Section view of main body modeling

C shape pipe was made of Copper pipe manufactured by bending and welding.(figure 14) Pipe shape was bent and the point part was made by lathe. After parts done, they were welded by each other to endure the tension and friction of the mechanism.

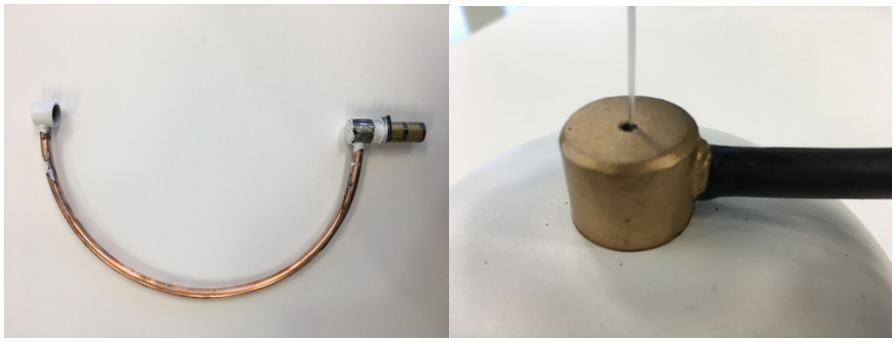


figure 14. C shape part overall and welding point.

figure 15. Upper part and down part of wire work.

After they were assembled wire passed through the pipe and were bind at the end of hoberman sphere. The other ends of wire were bind to pulley fixed at motor. (figure 15)

Motor bracket was designed to fit the size of motor shaped rectangular without one side. These were fixed by the bolt and nut using the fixing part of the main body. Also, for the potential meter was fixed with bolt and nut that it had in itself.(figure 16)

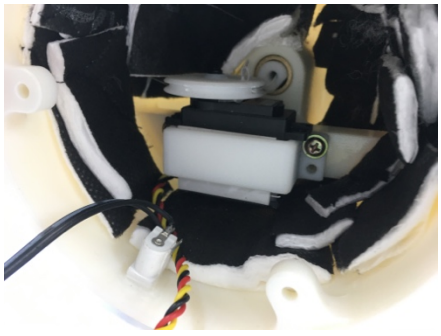


figure 16. Motor bracket and inside fixing of the product.

Software

I used Arduino uno. It was programmed that position of servo motor was 0 at the first time of using. It has 3 programs of breathing. Each breath consists of (1)inhaling for 5 seconds, exhaling for 5 seconds, (2) inhaling for 4 seconds, holding for 7 seconds, exhaling for 8 seconds, (3)inhaling for 7 seconds, holding for 4 seconds exhaling for 8 seconds, holding for 4 seconds. The breaths were coded on a time basis, with each cycle being 10, 19, and 23 seconds. It is designed to reset the system time after 10 seconds and restart from 0. They time based graph is shown below(figure 17).

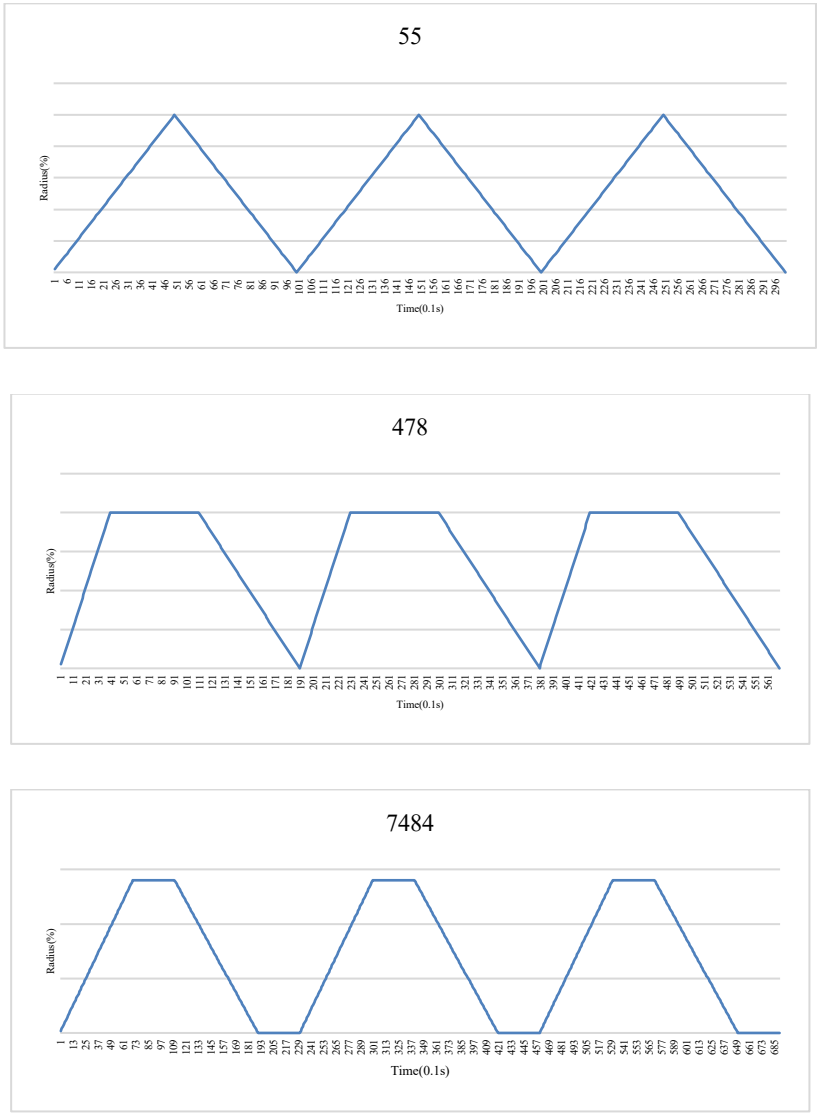


figure 17. From the top, how the position of servo motor is programmed depending upon the time interval. Y axis mean position or the radius of hoberman sphere, X axis means time interval, 0.1s. The name of graph shows the breathing method.

It is designed for experiment and it can be variously modified. It is also possible to insert functions such as Sin and cos, log functions, and so on.

Software is coded that when the jog dial is turned in order, the mode is changed. If I use the jog dial which can be turned many times, I can add more modes.

Design Study

Experiment Goal

I hypothesized that it would be effective to convert to tangible through the above processes. But at this point, I should determine whether the volume change of 3d can function similar to the 2D app to do breathing exercise, that is, people can breathe through the product. Also, I have to figure out the difference on the breathing exercises introduced between by the product and apps.

Experiment Procedure

This section, I presented the process involved in our experiment, including how to check breathing data, procedure, and materials used.

Obtaining breathing data

The most significant factor in this experiment is how to measure breathing. Currently there are several ways to measure breathing. Firstly, what is being used is to measure the nose and mouth, the inspiration and exhaust of the respiratory tract. Through this, the user can obtain the most information among the proposed methods such as the actual volume, the breathing cycle, and the volume of the vital capacity. There is also a way to measure through changes in temperature when you breathe through your nose and mouth. This is a method of measuring using pressure changes in the respiratory tract.

The second is to use volume changes in the chest when breathing. When a volume change is made by using a stretch sensor, there is a method of measuring through the resistance change of the sensor. It is also included in this approach to utilize the distance from the camera to the chest using a radar sensor.(Anitori, 2009) Utilizing a piezoelectric sensor is also included in this method.(Bhaskar et al, 2013) The way to use this sensor is as follows. Use a belt to form a middle part of the belt with elastic fabric. Use a rubber-like epoxy on the front of the piezo sensor. Attach the back of the sensor to the opposite side of the outer surface when the person is wearing it. This allows the person to breathe and whenever pressure is applied to the sensor, the sensor can produce power and determine whether or not to breathe through it.(figure 18)(Bhaskar et al, 2013)

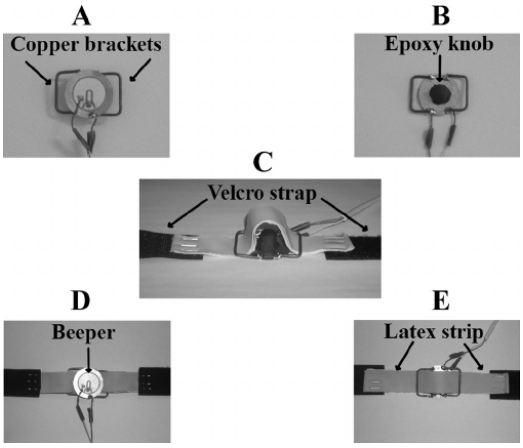


figure 18. The way of making respiration sensor using piezo sensor mentioned at Bhaskar`s paper

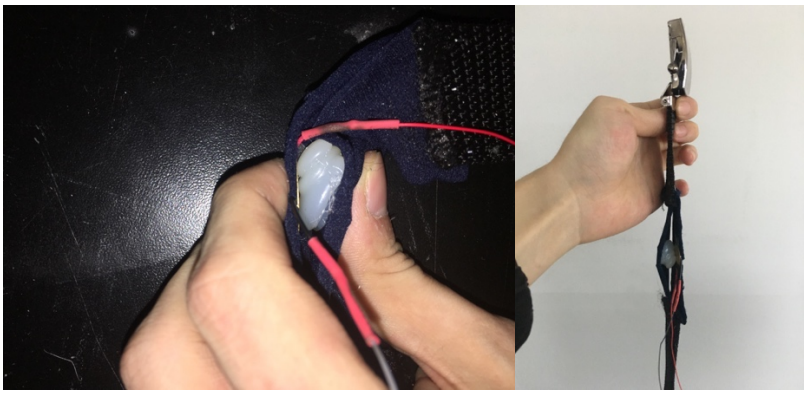


figure 19. The actual belt used to check respiration

Mobile Application selection

In selecting mobile applications, I have focused on breathing method. I have selected applications with three breathing methods obtained through previous literature reviews. CALM is an application that provides 5 seconds of inspiration and 5 seconds of expiration. BREATH 478 consists of 4 seconds of inspiration, 7 seconds of breathing, and 8 seconds of breathing. Finally, the BREATH consists of 7 seconds of inspiration 4 seconds of breathing, 8 seconds of breathing 4 seconds of breathing. The three applications mentioned above were selected because of the breathing method used for relaxing, the breathing method used to bring sleep well, and the breathing method used in yoga.

Recruitment

The most important factor in this experiment is how to measure breathing. I recruited 10 people of target group, stationary workers or students who sit at a desk and work or study. Their average age is 27 and standard deviation is 2.4. The gender ratio is 6 to 4, male to female.

Study Procedure

I conducted an in-lab study with three steps, questionnaire, following the apps and the product with the same program each and interview. I conducted 'Questionnaire' to figure out the habits of deep breathing in their daily life. The purpose of 'following the apps and the product' is to identify whether there was a difference between apps and programmed product in terms of breath data. Last, I conducted semi-structured interview to figure out the differences between two in aspect of their experience and the differences between themselves.

In questionnaire, I asked participants about habit of deep breathing, whether they do normally deep breathing in a daily life, and if they do, I asked about when and why for that deep breathing. I also wanted to figure out the use of breathing application or product that helps deep breathing or diaphragm breathing.

In following the applications and product section, I utilized the within subject design. Each person has their own respiratory pattern, and they have different lung capacity. If a person with the same habit pattern of breathing sees and watches two different breathing instructions, the product and the application can be compared. As I could not find a person with the same breathing pattern, I chose within subject design. For reducing the order effect and learning effect, the order of following breathing was generated upon the Latin Square. I deployed the application and the product that have same program at least one order away between each other. The table below is the Latin Square that I utilized in this study. (table 1)

Order	1	2	3	4	5	6
P1,7	7484(App)	478(Product)	55(App)	7484(Product)	55(Product)	478(App)
P2,8	478(Product)	7484(App)	55(Product)	478(App)	7484(Product)	55(App)
P3,9	55(App)	478(App)	7484(App)	55(Product)	478(Product)	7484(Product)
P4,10	7484(Product)	55(App)	478(Product)	7484(App)	478(App)	55(Product)
P5	55(Product)	7484(Product)	478(App)	55(App)	7484(App)	478(Product)
P6	478(App)	55(Product)	7484(Product)	478(Product)	55(App)	7484(App)

Table 1. Experiment breathing order to get rid of order effect and learning effect, using latin square

Participants were asked to do deep breathing following the given instruction by the applications and products with belt on six-times for each breathing method. While the section was conducted, the breathing data was collected through the belt every 0.1 second. For more precise data, they were

asked not to move their own body from the beginning of the experiment due to the data fluctuation. Before every trial of this section, I had checked the breathing data every time before deep breathing. The data obtained from the sensor was recorded in MS excel. Participants were asked not to be affected by sound generated while the experiment. This was notified before every experiment.

In the interview section, it was conducted as semi-structured interview asking the differences occurring in terms of breathing, for example they were asked “Was it hard following the product difficult or natural when moving from exhalation to inspiration or holding?”. And I asked the vision of participants whether it was fixed on a point or overall product. Following those kinds of questions, I asked questions about the product itself. I asked questions such as whether there were difficulties in copying breathing through products or what were the disadvantages as products.

Result

Questionnaire

Questionnaire results are shown below.(table 2).

Question	The number of “Yes”	When and Why
“Do you normally do deep breath in daily life?”	5	-At the morning, to get fresh air -Yoga, for the exercise -Yoga, for the exercise -Before Sleep, to get to the sleep -After eating dinner, to be awaken
“Have you ever used an application or product inducing deep breath?”	1	-2years ago, paid app was distributed free

Table 2. Result of Questionnaire

Half of the participants do deep breath in their daily life, and their purposes were different each other. And only one person had utilized the breath app, but it was not for the deep breath. The participant downloaded for the curiosity due to conversion to free.

Following the applications and product

Three example data graphs of P10 are shown below.(figure 20, 21, 22)

figure 20. Result of P10 on the breathing method, 55, 5 inhaling and 5 exhaling. X axis mean the time of 0.1s, Y axis indicates the sensor value

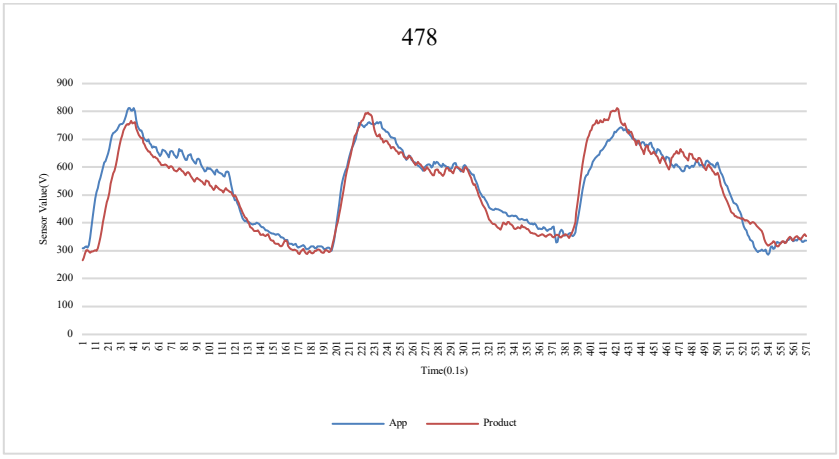


figure 21. Result of P10 on the breathing method, 478, 4 seconds inhaling, 7 seconds holding and 8 exhaling.

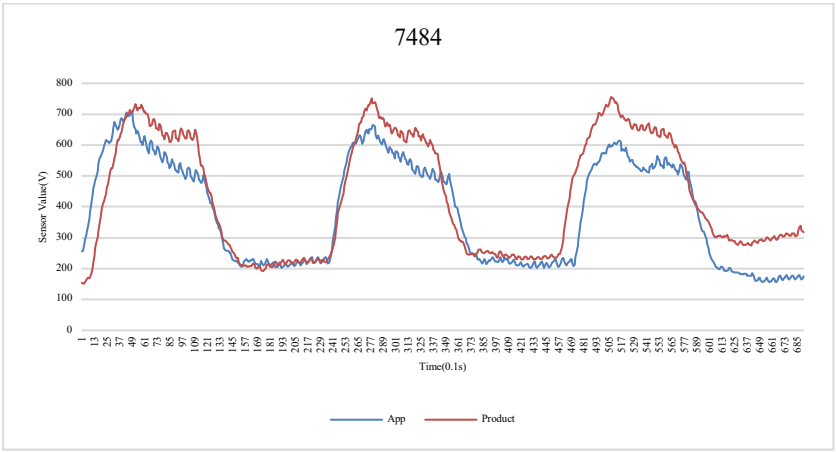


figure 22. Result of P10 on the breathing method, 7484, 7 seconds inhaling, 4 seconds holding, 8 seconds exhaling and 4 holding.

X axis of the graph is time and the unit of it is 0.1 second. Y axis means the value of piezoelectric sensor value ranging from 0 to 1023. Among six breathing data, three data range was selected upon the learning effect and minimum value. After the data was plotted in same plane. Examples of another participant are shown below.(figure 23, 24, 25)

figure 23. P5 55 breathing graph

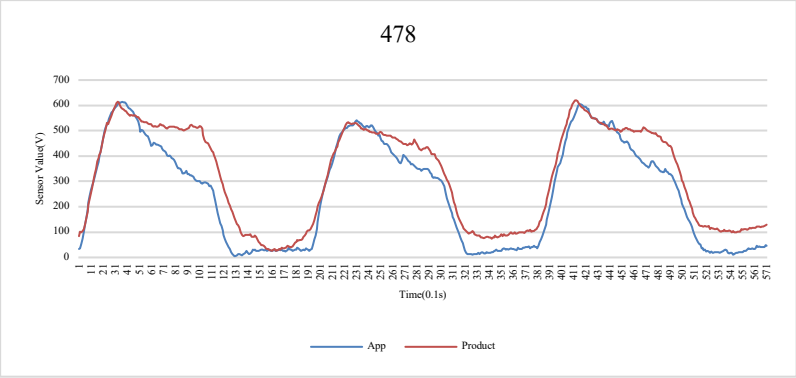


figure 24. P5 478 breathing graph

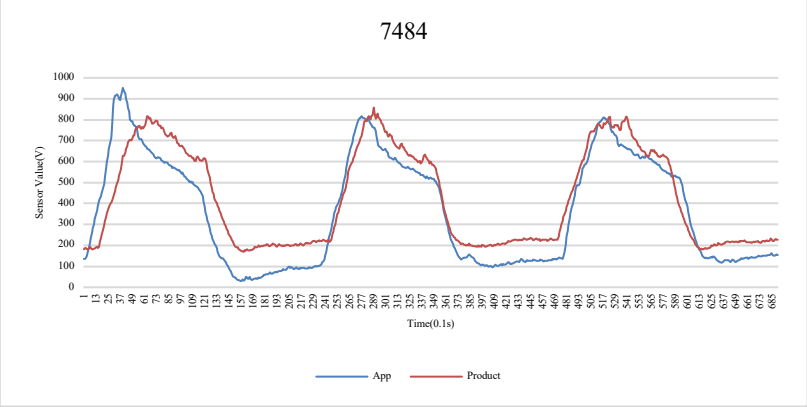


figure 25. P5 7484 breathing graph

Upon two graphs set of participants, the data range of sensor value is variable due to the sensor sensitivity variation due to the tightness of the belt. Our interest on the data is not the actual sensor value but the waveform of the graph, how it looks depending on the time variable.

Analysis

Respiration graph

Main goal of analyzing the graph is to find the similarity between two graph wave form, not the actual value. Due to the variation of data range of sensor, first, I should refine the data. To compare the waveform of two graph generated by the app and the product, translation and uniform scaling was used(standardization). The equation for translation and uniform scaling is shown below.

$$z = \frac{x - \bar{x}}{S}$$

Z = Normalized value of data
S = Scale, RMS scale of data
x = data
$\bar{x}$ = Average of data group

In this formula, z means normalized value, x means each data, $\bar{x}$ is average of sample mean and S is a root mean scale. All data in a one trial were translated into z score for putting the data on the same scaling. Graphs below is showing data with standardization, same participants with figure 26,27,28.

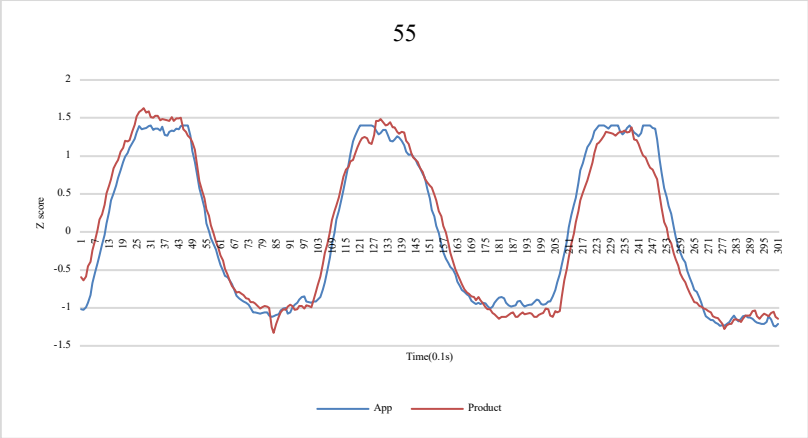


figure 26. Normalized graph of P10, for the 55 breathing technique. Y axis is standardization value, X axis mean time interval, 0.1s

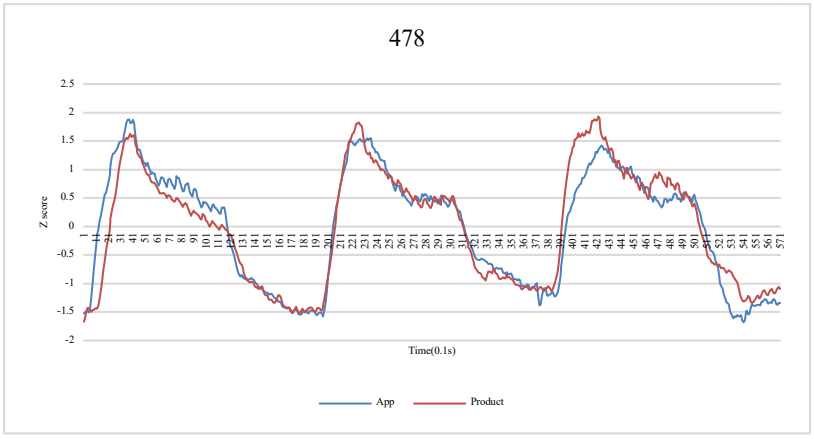


figure 27. Normalized graph of P10, for the 478 breathing technique

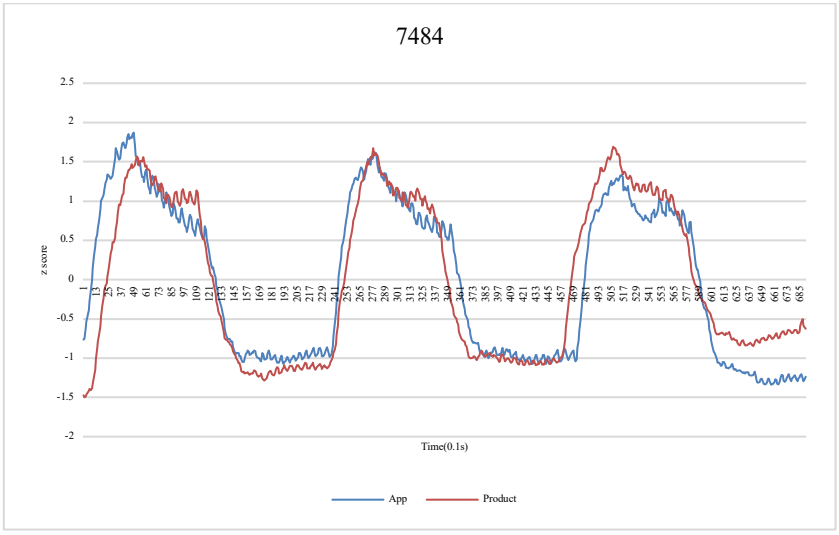


figure 28. Normalized graph of P10, for the 7484 breathing technique

The data ranges of the app and the product(P10) were uniformed and through this we can compare the similarity of two generated graph. I could figure out the graph for P7 under below.(figure 29, 30, 31)

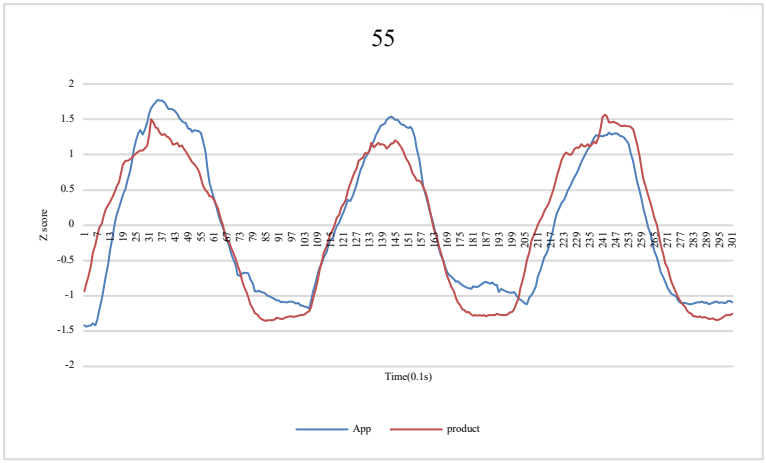


figure 29. Normalized graph of P5, for the 55 breathing technique. Y axis is standardization value, X axis mean time interval, 0.1s

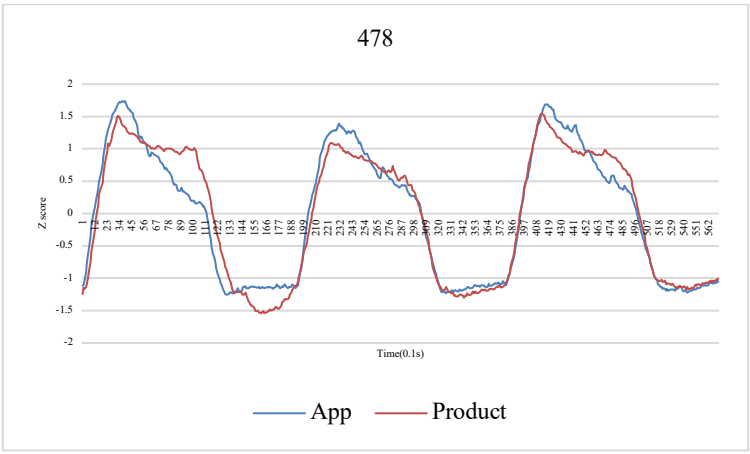


figure 30. Normalized graph of P5, for the 478 breathing technique

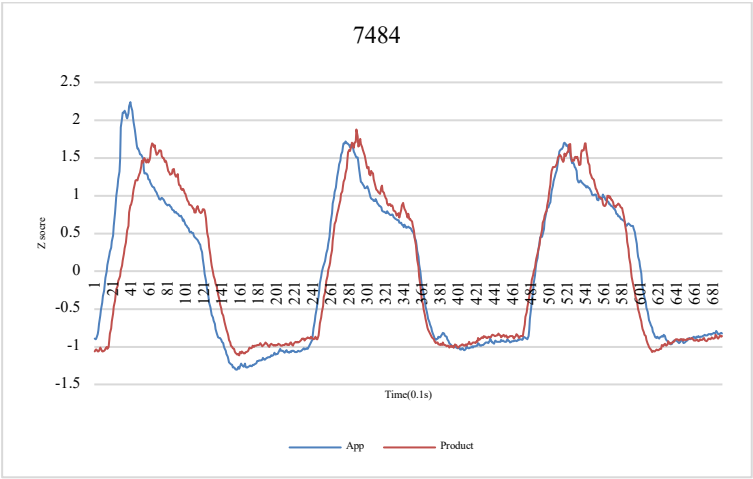


figure 31. Normalized graph of P5, for the 7484 breathing technique.

Through this process, I can compare the waveform of the data got from the experiment. In comparing waveforms of a graph, it was necessary to check the correlation between the two graphs. In this study,

I could quantify the similarity between two graphs using Pearson correlation coefficient. But the Pearson correlation coefficient means only similarity or the linear correlation not the percentage of similarity. Using Pearson correlation coefficient, I could find the 30 coefficient of 10 participants.(table 3)

Participants	Pearson coefficient 55	Pearson coefficient 478	Pearson coefficient7487
P1	0.72868419	0.86792516	0.90645996
P2	0.83296401	0.89257911	0.95910864
P3	0.88763745	0.903842	0.94802898
P4	0.72087923	0.61347831	0.42534736
P5	0.92879984	0.96548707	0.91482252
P6	0.86518348	0.93106515	0.92083552
P7	0.74511801	0.83420503	0.75080566
P8	0.93581667	0.95527574	0.93297134
P9	0.96033008	0.95172648	0.92392756
P10	0.97646621	0.94362701	0.90470297
average	0.85818792	0.88592111	0.85870105
average(except MAX MIN)	0.86056672	0.91003071	0.90031931
overall average	0.867603358		
overall average(except MAX MIN each)	0.89030558		

Table 3. Pearson correlation coefficient of each breathing depending on the participants. Average and average without MAX and MIN are calculated

The Pearson correlation coefficient represents a linear relationship with -1 representing a negative linear relationship.

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[\,n\sum x^2 - (\sum x)^2\,][\,n\sum y^2 - (\sum y)^2\,]}}$$

n = The number of pairs of values

Σxy = sum of the products of paired values

Σx = sum of x scores

Σy = sum of y scores

Σx^2 = sum of squared x scores

Σy^2 = sum of squared y scores

x = value of application

y = value of product

r means Peasron correlation coefficient. $\sum x$ is sum of x scores and $\sum y$ is sum of y scores. $\sum x^2$ is sum of squared x scores and $\sum y^2$ is sum of squared y scores. $\sum xy$ means sum of the products of paired values. In this research, x value is application breathing data, and y value is product breathing data.

Generally, absolute values between 0.7 and 1 represent a strong linear relationship, values between 0.3 and 0.7 represent a marked linear relationship, and values between 0 and 0.1 can be almost

ignored. The same is true for negative cases, and only that relationship represents a linear negative relationship.

On the table x, for each of the three breathing techniques, the values are 0.86 and 0.91, and 0.90 and the overall average of 30 data is 0.867. In other words, when the modified data increased while the inspiration caused by the applications, the modified data while the inspiration caused by the product also increases. Similarly, when data is reduced while looking at an app, the data by the product decreases as well. Namely I can see that the three functions of deep breathing, inhale, exhale and holding, worked at similar times in the app and in the product. And when comparing the relationship between the coefficient and the meaning of Pearson coefficient, it can be said that a strong linear relationship is shown. This analysis led to the conclusion that the two graphs were similar.

I could conclude that the deep breathing by the app and the deep breathing by the product were similar. This implies that the new solution, the product, provides almost same effect as the app in terms of deep breath.

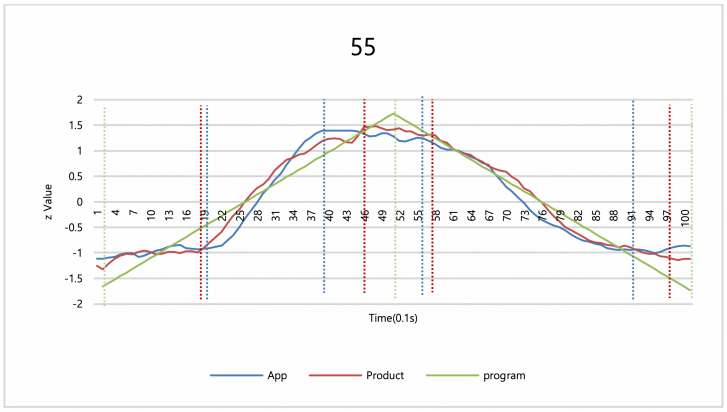


figure 32. One cycle of breathing method, 55, with the inflection point(time)

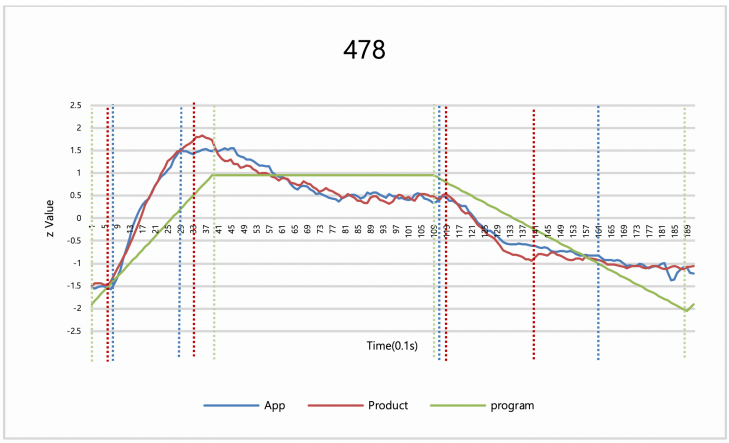


figure 33. One cycle of breathing method, 478, with the inflection point(time)

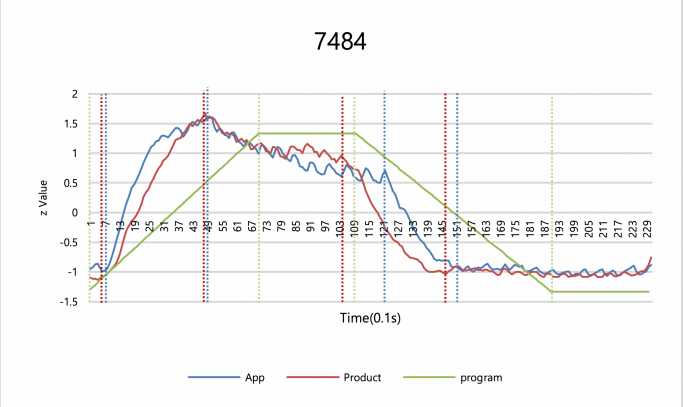


figure 34. One cycle of breathing method, 7484, with the inflection point(time)

The green dotted line is inflection point of breathing exercise, blue line is app`s point and red line is product`s point(figure 34). Time difference occurred when the instruction had changed. In other words, participants had difficult to follow the instruction as given. The difference scale was turned out due to reaction time and the breathing ability of each participants. When inhaling, participants normally had shorter time than given instruction. For instance, in case of breathing exercise of relax (5 seconds inhaling, 5 seconds exhaling), participants had inhaled for 3~4 seconds and exhaled for 3~4 seconds. They tried to inhale and exhale more for the rest of the time seeming like holding time. Similarly, this phenomenon consisted to rest breathing exercises causing shorter inhaling and exhaling time and longer holding time. I concluded that the following the given instruction was not precise as I expected. This phenomenon would happen all the times regardless of the breathing time. The breathing instruction are given as time or instructors` guide these days, but the time-based instruction system is not effective for making people follow the exact instruction.

Interview data

I generated transcription of 10 participants` interview records. Our first interest on the interview was the difference between the apps and the product in aspect of breathing that could not be obtained by the breathing data, difficulties of following the application and product, detail breathing difference etc. I also tried to figure out the disadvantages of the product and the potential of using.

Potential usage as a on desk product inducing the deep breathing existed. This product can be used as a product of mindfulness. It has potentials with various possibilities not only for the deep breathing but for other utilization. P9 highlighted "*I thought while doing an experiment, the first thing is, when I get the notification, I'll flip over. But I think I'll do it through the product."* P9 also mentioned *"The second thing I think about it, I can indicate sort of flexible workplace through volumetric expression on how much progress I've made, how focused I am, or how much time I work, how much time I rest etc. I feel like I'm out of steam, and when this grow bigger, I feel like I'm nervous."* P2 commented

"The feeling of mindfulness is a little stronger. If the size gets smaller then. I would rather use this as a mindfulness product." P8 commented *"I was more immersed because of the stereoscopic effect."*

To sum up, the movement can make people feel mindfulness or can this can be used in other way on desk. Possibility of using on the desk existed in aspect of breathing product that have volumetric change. Through Further research, I could identify detail potentials of this product in discussion section.

Summary

I could identify the power of mimicking breathing through product compared to the 2D application. Through this, it was turned out that the product had similar effect, but the breathing itself compared to the original program has different cycle. This was caused by the human nature on the breathing and the reaction time to recognize the changes. New way of instruction on breathing should be suggested, adding other factors or revising the program. As an on-desk product about the breathing, I glanced the potentials of using this. Breathing product could be on the desk considering their environment. Some defects like absence of indicator, size issue was obtained, for the further design, they could be applied to the new design.

Discussion

Breathing Instruction

Upon the findings from previous section, we could identify the minute difficulty of following a given instruction by 2D application and 3D volumetric change due to breathing habit and reaction time. The ways to increase the accuracy is left unsolved for designing the breathing product. I can suggest one way of designing breathing program. The system is composed of major three parts, breathing detecting system, breathing instruction system and user.

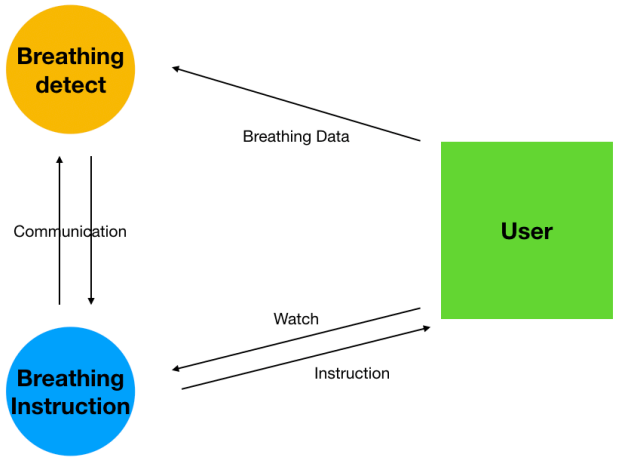
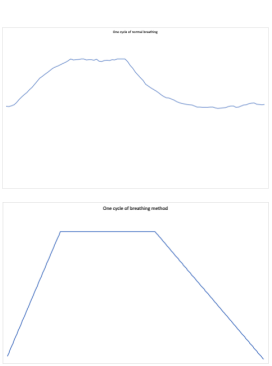


figure 35. Schematic of the new system.

Breathing detecting system obtains a data from the user using radar, stretch, or other ways. Breathing instruction system is product that can give instruction through anyways. User is breathing subject through watching the instruction or other senses. Detecting system and instruction system is communication in a real time.(figure 35)

The basic object of this program is gradually giving instruction depending on the breathing data. At the first cycle of the instruction, this system will not give perfect instruction as breathing pattern such as 5 seconds inhaling and 5 seconds exhaling. It will give instruction more related with their status. More steps proceed, instruction will be fit to original breathing method. Like this kind of algorithm, it can give people enough time to adjust to deep breath method.



	1cycle	2cycle	3cycle	...
Reflection Rate	100%	90%	80%	...
Reflection Rate	0%	10%	20%	...

figure 36. Reflection rate and cycle for new breathing suggestion

In this algorithm, the breathing instruction will assimilate to the original method gradually. Users will be adopted to instruction from natural breathing to method (figure 36). During this section, I can also put the system that correct the error time and reflect to the next cycle.

3D Volumetric Change, Skeleta vs. Covered

In this scope, I defined skeletal as frame based design and covered as plane based design. I could figure out that product have similar effect on do deep breathe which is normally induced by the 2d display, application or wearable device. Through the analysis, physical volumetric change can be presented to cause deep breathing. But this cannot imply that 3D volumetric change can have same impact as the product. During the experiment, I asked participants whether they watch whole 3d volumetric change or specific part of the design. 7 participants said that they watched whole volumetric change and the rest said opposite. At this point, I can argue that skeletal design had disturbed participants to watch overall due to ambiguous guideline. I can assume that participants would have seen the whole shape if they saw the covered because it was difficult to find out explicit guidelines due to the skeletal design.

Time-based Instruction

During the interview, one participants pointed out that abstract information is much better. He said that abstract information was rather helpful. He said it was much more natural than following the app, and talked about the complaints in the app.

P9 commented “The app showed seconds, so I felt a lot of information. 4 seconds, 3 seconds, 2 seconds make me urgent feeling, I feel like a game over when I left. In case of product, I like due to no information. Applications make me that I have to focus on something, so I do not know whether I did a fit, meditate or play a game.”

In case of breathing exercise, I have to think of the way of information I should serve. As an on-desk product, this product should not disturb users what they are doing. Also, I should not force them to do breathing in a right way, that could be uncomfortable for users.

I should check the effect of abstract information in aspect of breathing and on desk product each. If the goal is making user follow the right breathing method and training, then giving them a concrete information is adequate. But in aspect of on desk product, I should think context of using it and their natural behavior of breathing so that I can program or set a product for better usage.

Potential Use as an On-desk Product

An experiment for finding the potential of the product when in its context was conducted. 5 participants were participated in this experiment.

Tasks	Time	Purpose
Using laptop, typing	15minutes	On-desk behavior
Reading a book	15minutes	On-desk behavior
Writing a letter	15minutes	On-desk behavior
Interview	30minutes	To find out the reason for the behavior

Table 4. Process of experiment

During this task, the product was working covered with acryl box to reduce the sound. While product in on, participants were asked to focus on required tasks. This behavior was observed and recorded in diary.

figure 37. the environment of the experiment

Through this experiment, I could figure out some findings. First, this product was regarded as a mindfulness product when it was working. P1 commented “When I saw this product, I feel relax due to the movement. I think this movement looks like making me calm.” P3 said “This looks like pendulum. For a short time of rest between work, I just keep watching it.” Second, following the product was generated. P1 told “While I was watching it, I don`t know the reason, but I unconsciously matched my breathing with the product.” P4 said “It feels like the battle cry, ‘left right’ in the army. I just don`t know the reason but it feels…”

Limitation

There are some limitations. First of all. As a product, there is a limit to the current sound, and this may have affected the results of the experiment. But in this design study, only two participants said that they were influenced by the sound. They told that the sound was not a big issue but it acted as a cue sign when holding was change, holding to inhaling and holding to exhaling. The other participants answered 'No' to whether they were affected or not. They said that they just watched the movement of the product. But it would affect the participants while experiment unconsciously. In meditation, sound is an important factor. However, it is impossible to eliminate sound in the current structure is designed. By solving this problem through the structure of changing the motor or preventing the noise inside, you will be able to find out whether it is easier to induce value or breathing as a product. In the future, I expect to remove the sound and unify the environment of the experiment so that the experiment can be conducted under control.

Second, people have very different breathing patterns. If the breathing pattern changes, I think that coping ability as a product is needed. Currently, only three programmed parts are provided, but it is very important how to provide breathing according to people's breathing patterns. As mentioned above, many breath measurement techniques have been developed. However, it is a reality that measuring respiration differently from other bio-signals has many limitations. For example, it has to be kept quiet, or the sensor must be placed at the skin or thin edge. For higher value of this product, it is important to pattern respiration and provide a program suitable for the user. The way of giving instruction was suggested, but the best suitable program should be figured out and analyzed. The matching rate or the time difference occurred should be checked for serving the most suitable algorithm.

The last is the limit of breathing method. Although many breathing methods are presented, there are not many kinds of breathing methods suitable for all situations. Since there is a part that cannot be resolved by breathing, it is anticipated that it will be possible to add a new breathing method or an additional element to the product to provide a breathing method or additional function for various situations using like light or sound.

Conclusion

Summary and Findings

I propose a Breath-Time: Breathing exercise product through the volumetric change for meditation, stress relief and other purposes. Through in lab study using breath time, I was able to investigate breathing upon the product and potential of product use.

I found through experiment that there is no significant difference in do breathing exercise through the 2d display and through volume changes. In other words, it can provide unobtrusive effects that are different from currently used products. As the breathing through the volume change is generated, various volume changes can be considered. In addition, I have seen one possibility for volume change interaction, and it can be used variously except for breathing. I have also seen the possibility of using it as a top product, and I will be able to offer products that meet the target user in the future.

Breathing through apps and products could not be followed exactly by people. This breathing instrudction, or time-based instruction, should be considered. Depending on the purpose of the instrcutions, several options are existing for better instruction. For exact following, new system should be suggested and generated. For other purposes like meditation or mindfulness, the abstract information instruction is considered better, that is multi-modality approach.

I could see the possibility as a product on the desk. Some have talked about their size and some about their expansiveness. Someone talked about the potential for future development as a product for students and stationery workers. It will have no problems in breathing, will show potential for use on the desk and will provide benefits to the target user. However, in the case of the breathing method, it was necessary to provide it to the individual, through which the individual would have the effect of relaxation and meditation.

Expected Contribution

Breathing is essential for everyone. However, such breathing methods as deep breathing are not necessarily required for everyone. Depending on the situation, it can be applied to many situations, such as when you want to relax or meditate. Also, in many cases breathing method is often followed by instructor, but through this product, it is not necessary to follow their word. In the future, I think that it can be applied not only to the meditation applied to the breathing method but also to the fields such as exercise and medicine. I think it can be used for various purposes such as for children by adding fun elements.

Future Study

How to serve the program that have people breath accurately compared to the breathing exercise should be suggested and tested. In this study, I suggested one way of solution but there are a lot of ways that reducing the time difference.

Covered design would be evaluated on how much it is organic, suitable to breath and emotions or affectiveness caused. Obviously skeletal design and covered design have different impact as a product.

In the future, depending on the number of candidates made, I can also evaluate affective or emotional difference upon the materials used. Through this I can find out the most suitable design for Breath time.

This intermediate product has a single modality of visual, physical volume change. Upon the previous finding, I can do multimodality approach to this product giving the abstract information or concrete information about breathing time. Through this process, I can examine the difference between single modality and multimodality and the difference between giving abstract information or concrete information. Through this I can conclude which will give the most suitable product in case of inducing breath.

Engagement on the product could be evaluated. It is hard to define the engagement of the product, but through the field research, I can compare which will have better engagement among applications or the product.

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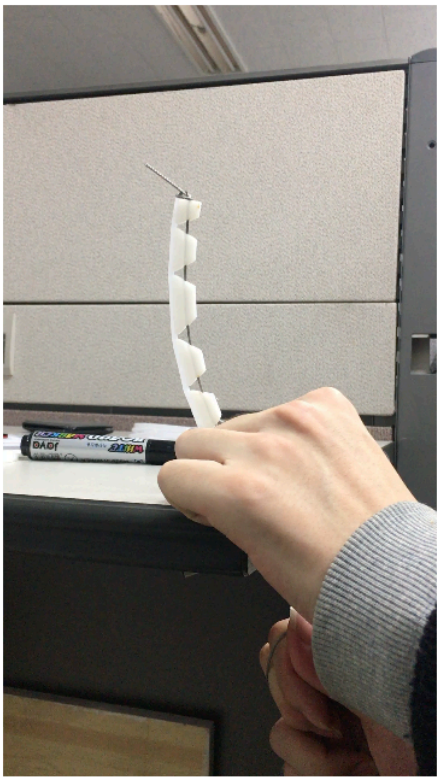
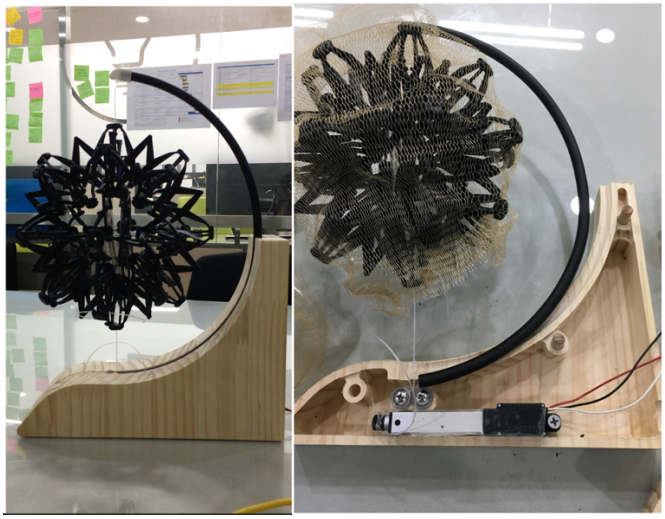
Appendix

First Design of Breath Time and Initial Prototype

First mechanism test prototype.



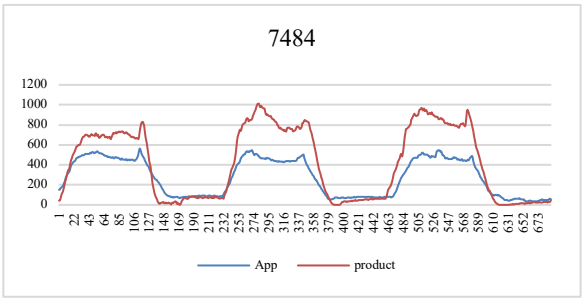
Left side of picture is robot hand mechanism using wire and Right side of picture , C shaped pipe is established as horizontal. Both was mechanism test prototype for the Breath Time.

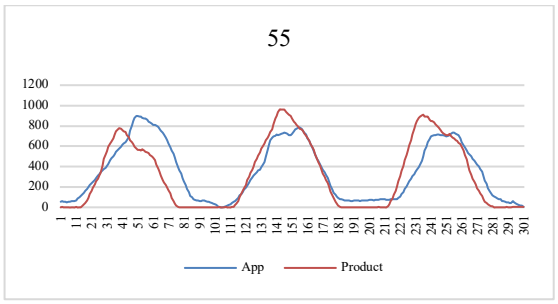


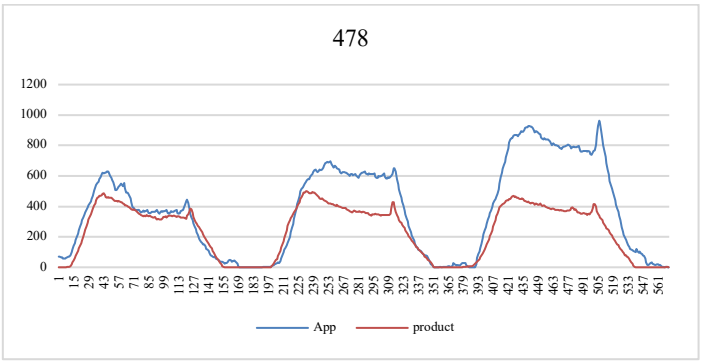
First initial prototype of Breath time design and the implementation of it. Linear servo motor was used to do physical volumetric change. Due to mechanism limits and the time limitation caused by mechanism, it was revised to the Breath time suggested in this paper.

Data of particpants

P1 Breathing data







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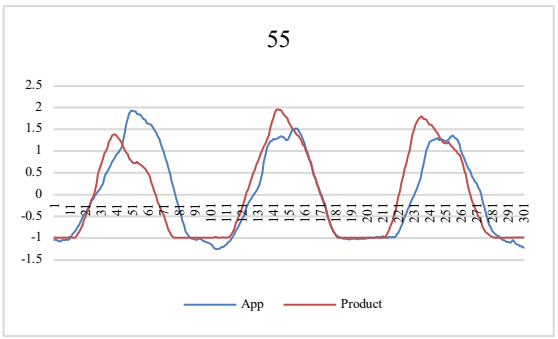

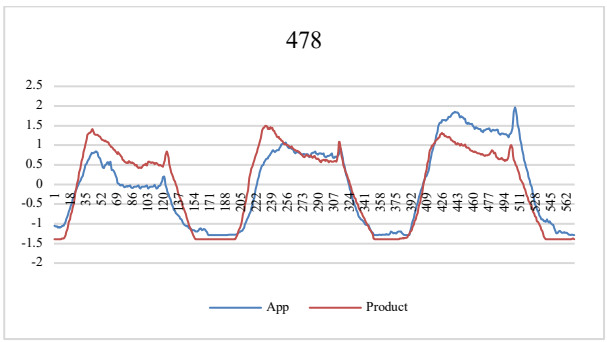

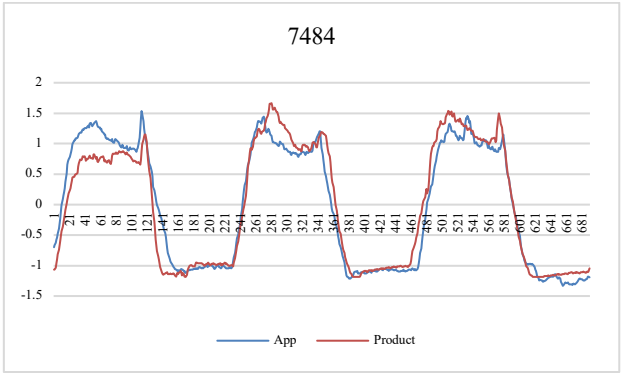

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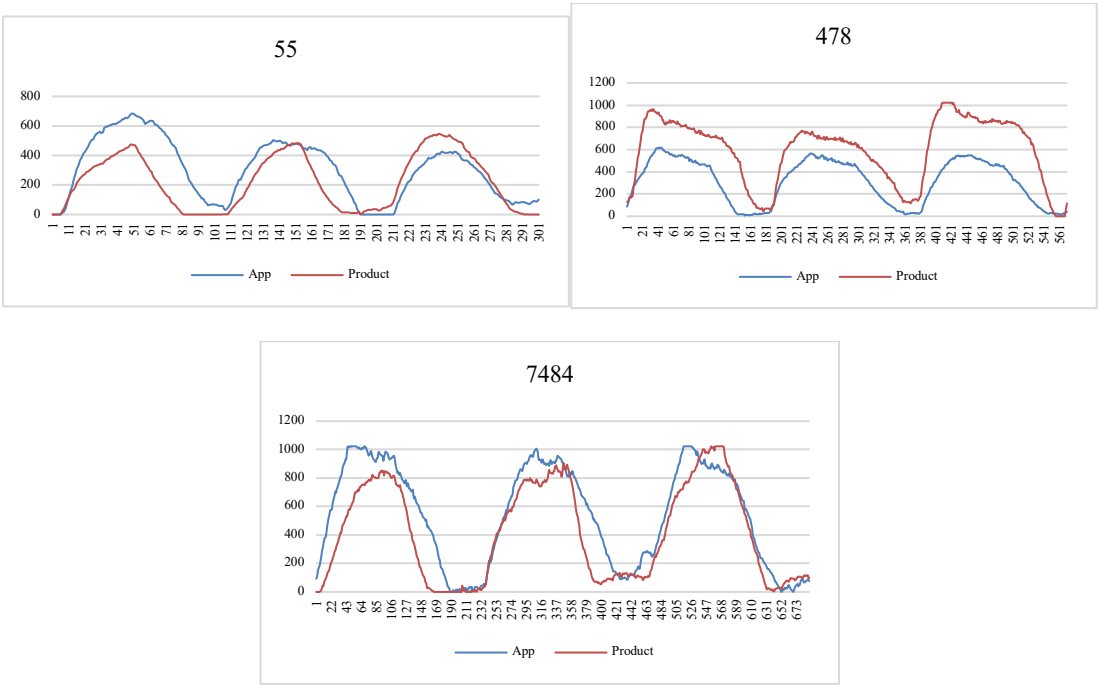

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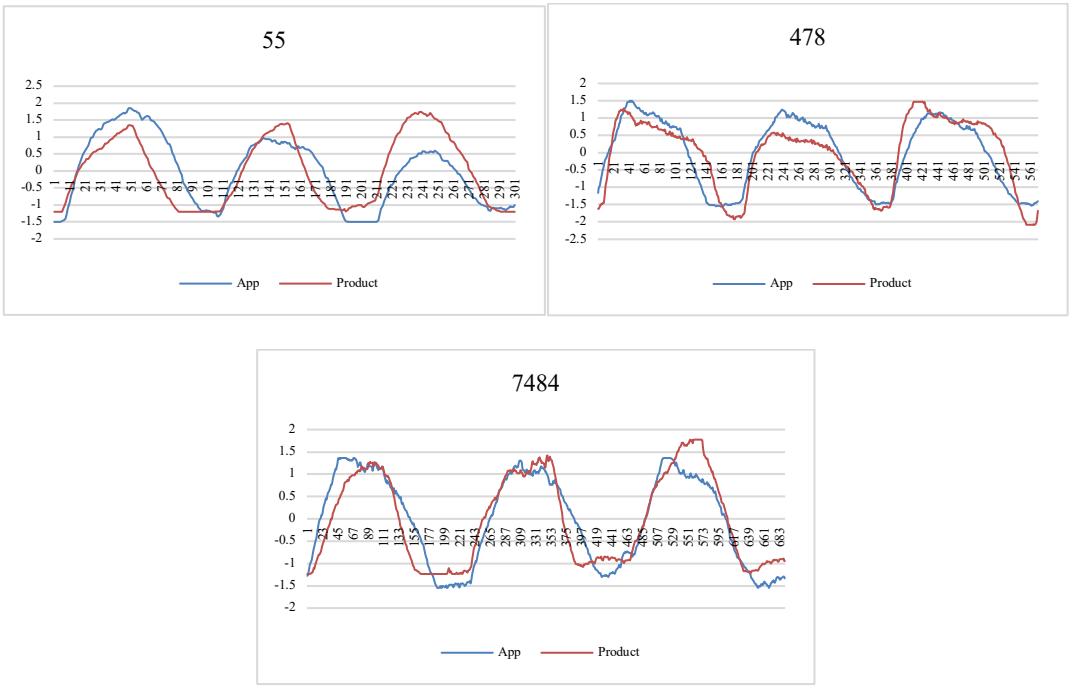

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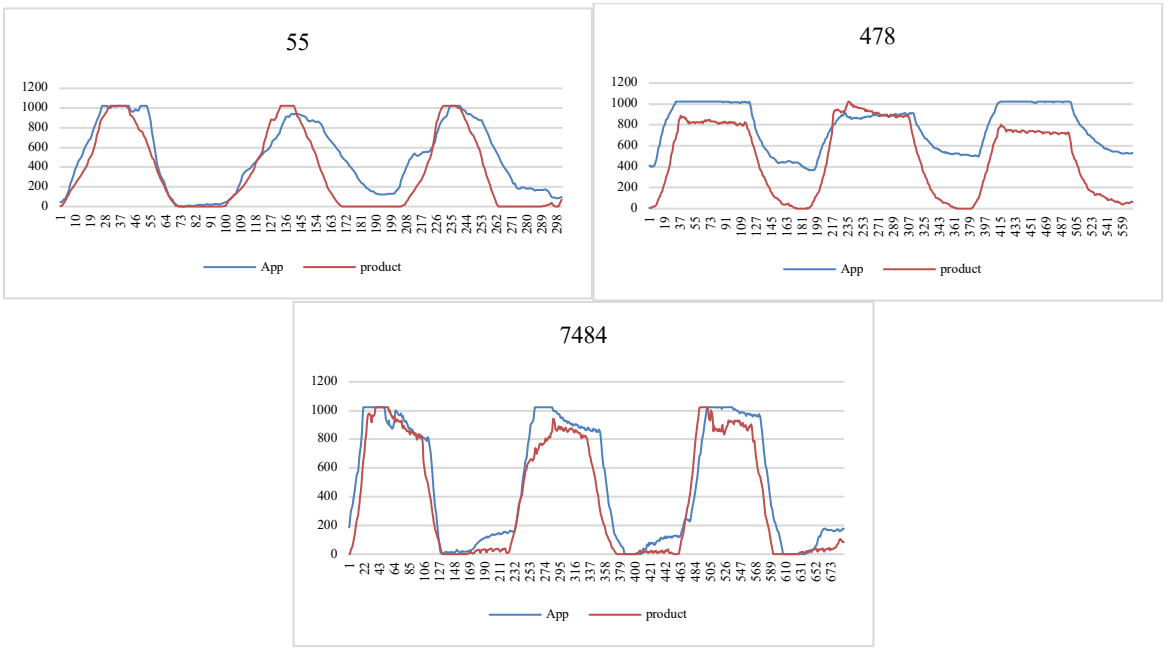

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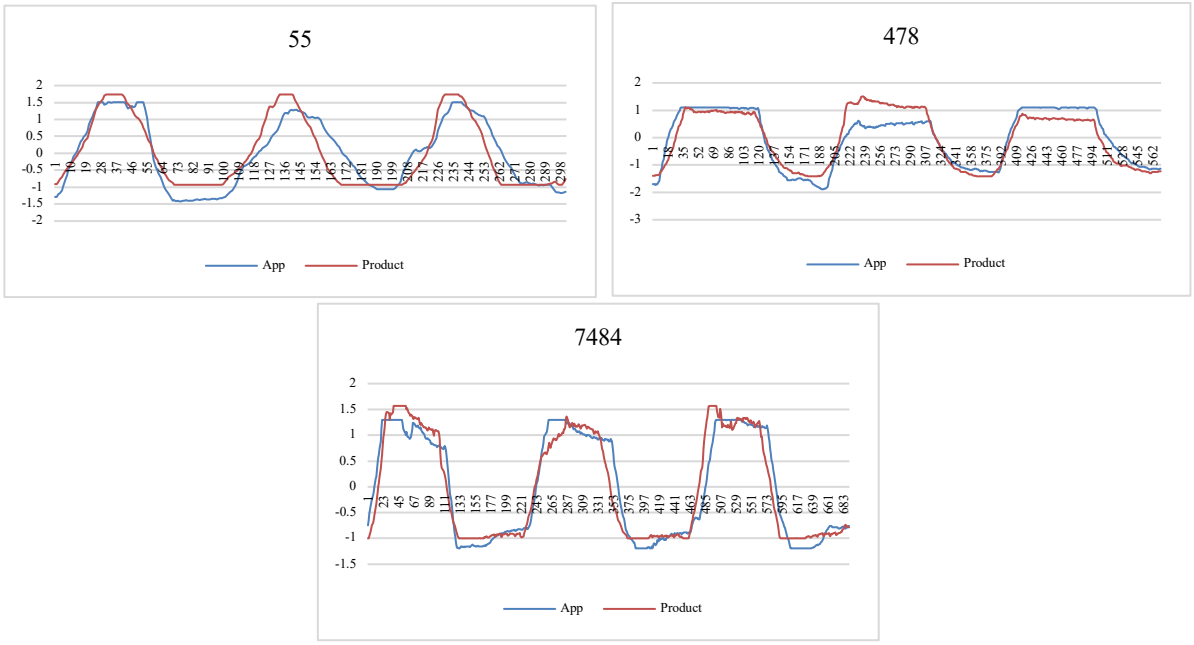

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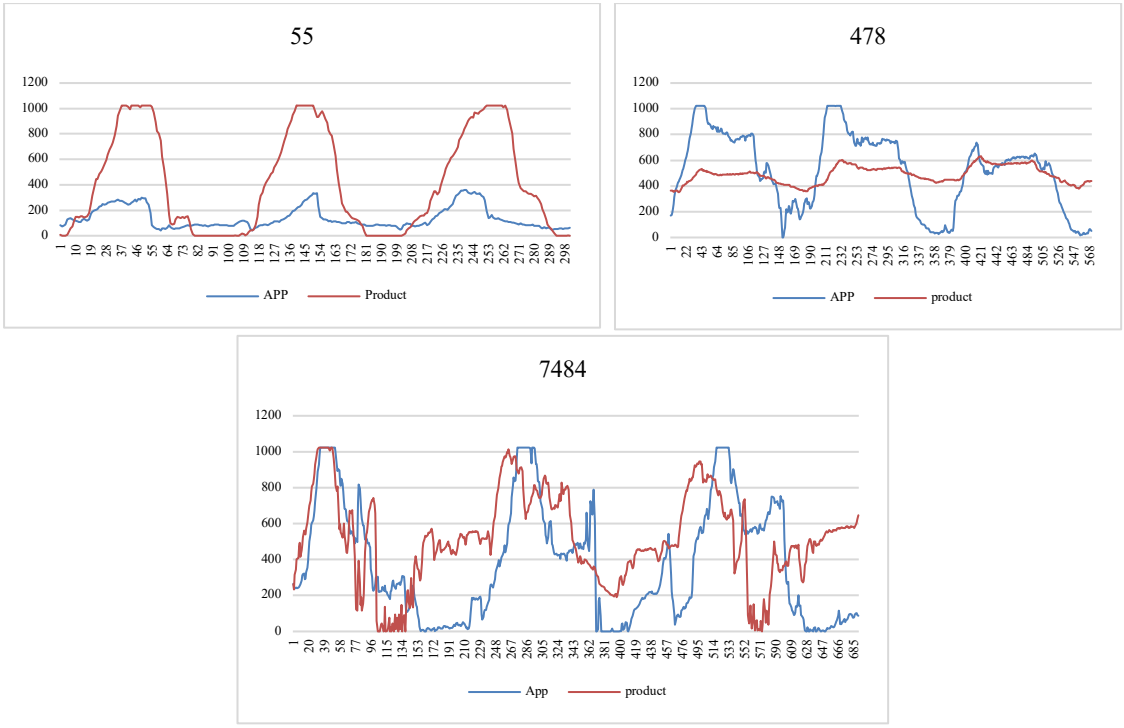

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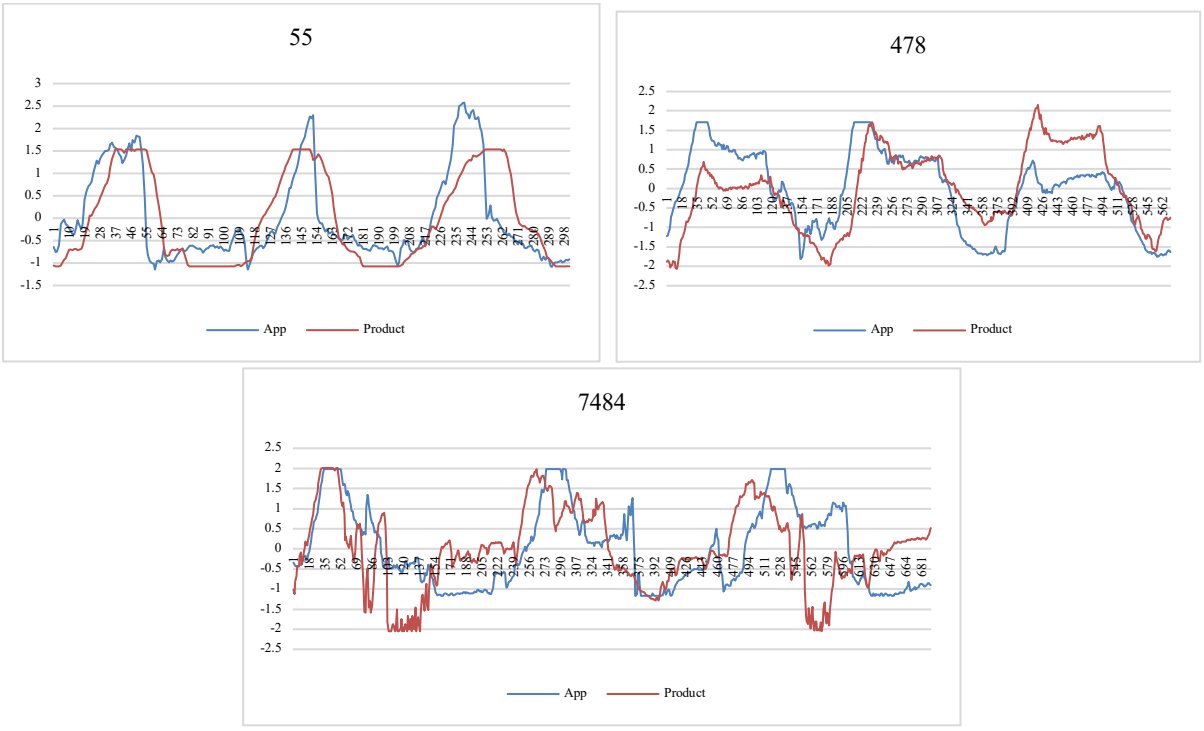

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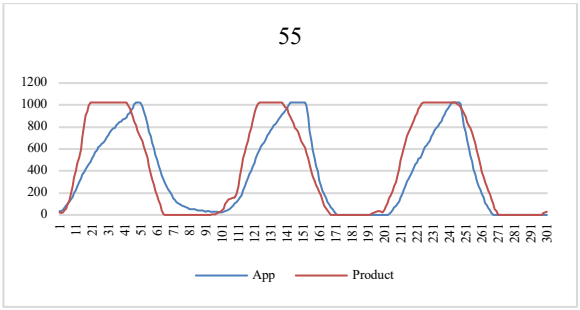

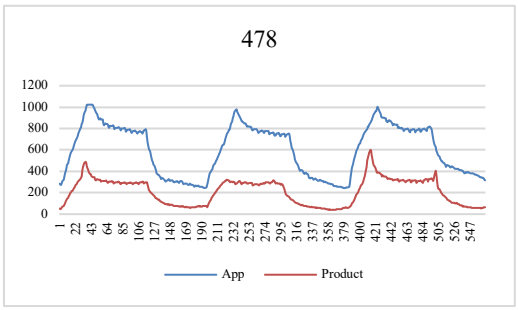

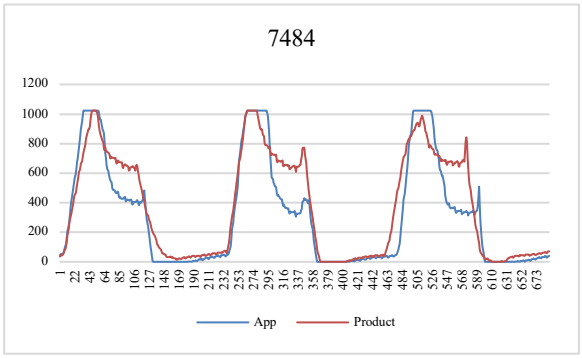

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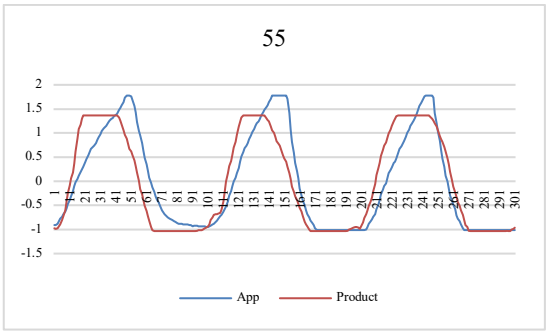

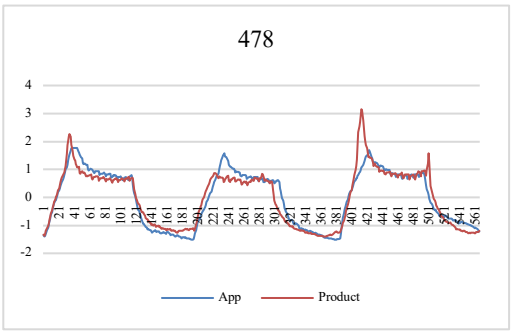

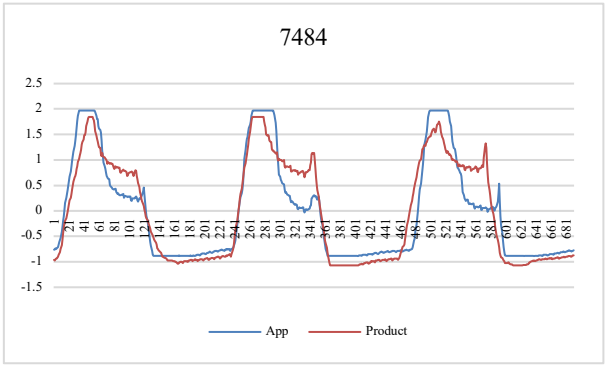

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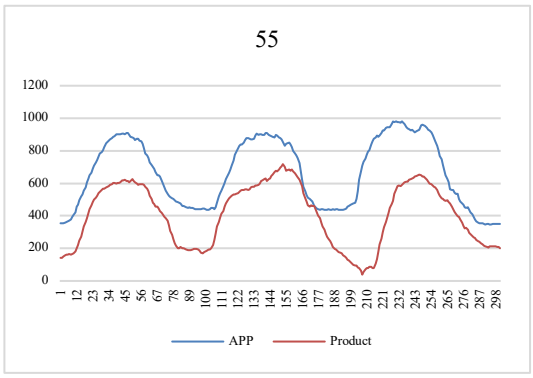

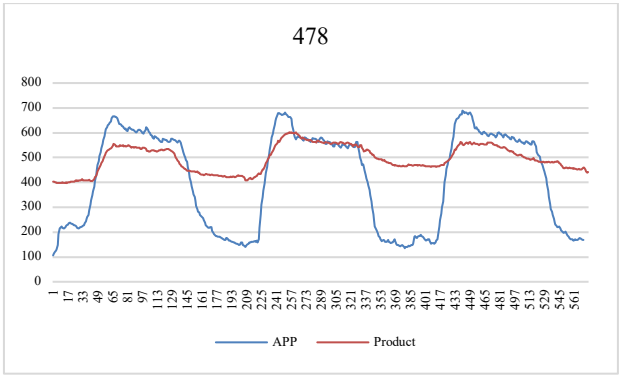

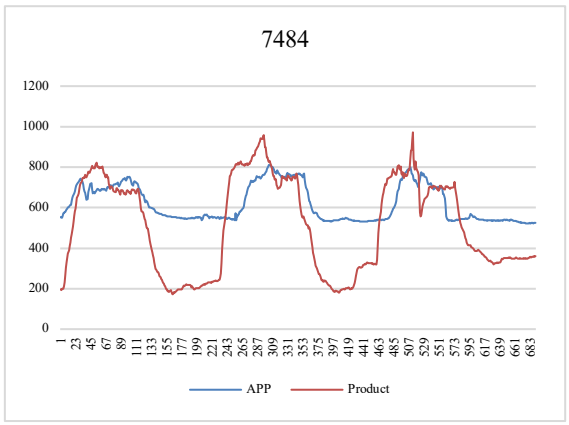

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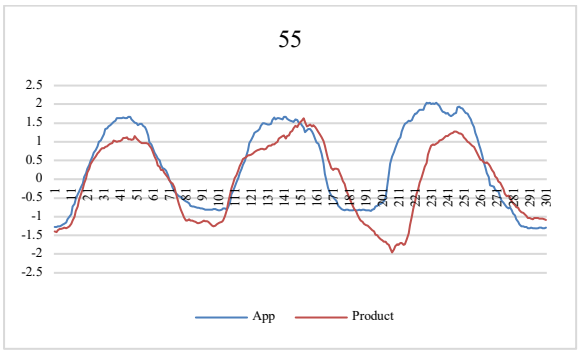

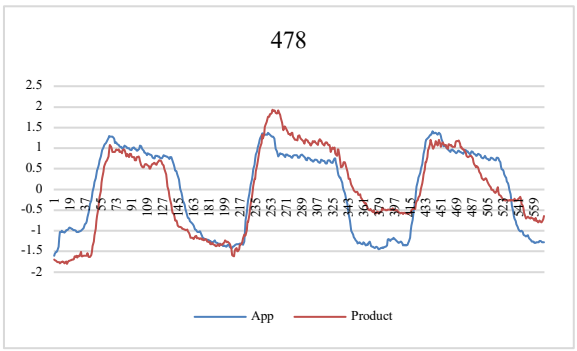

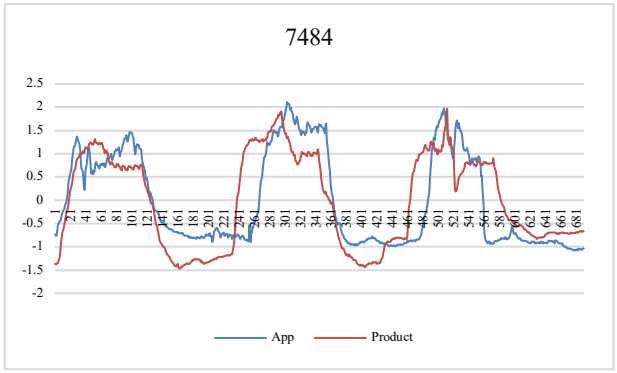

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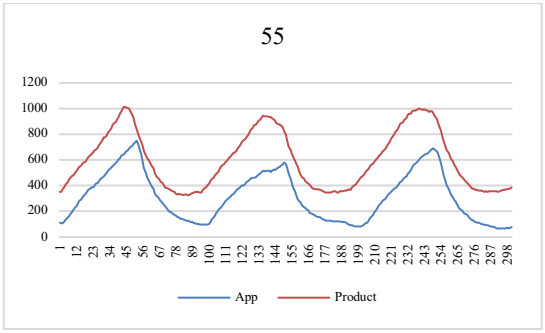

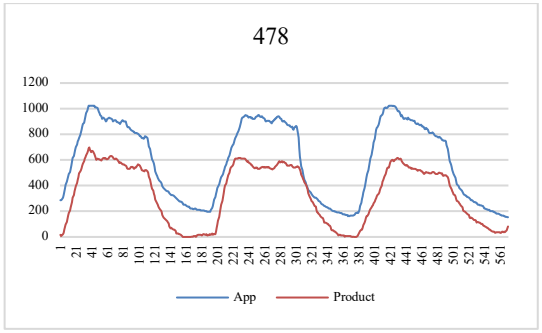

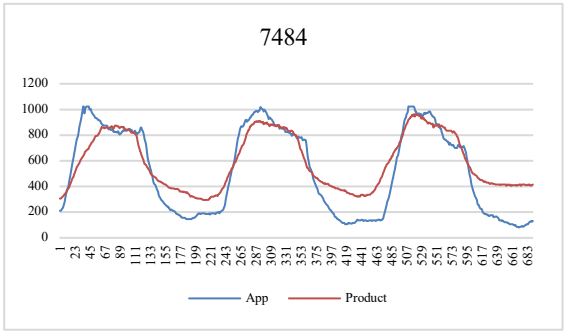

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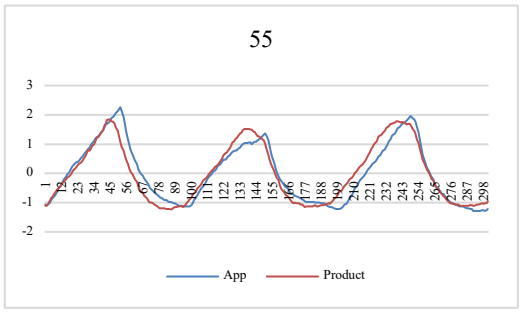

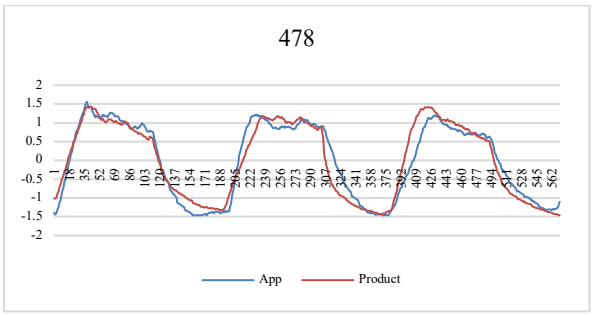

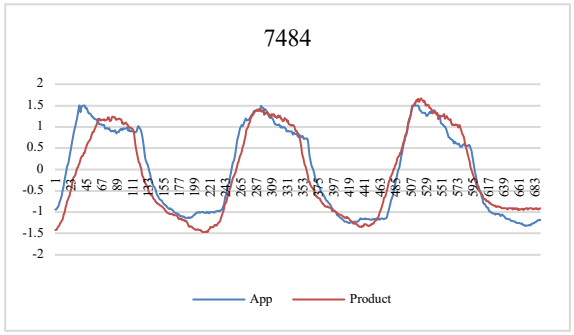

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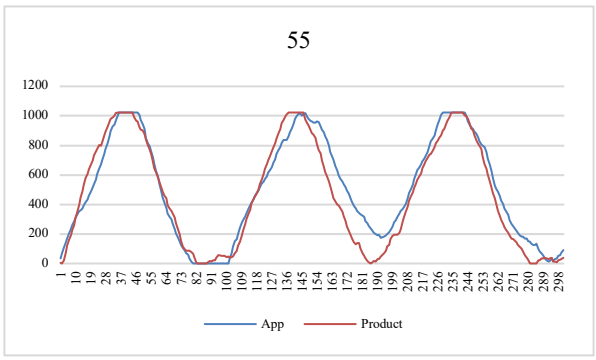

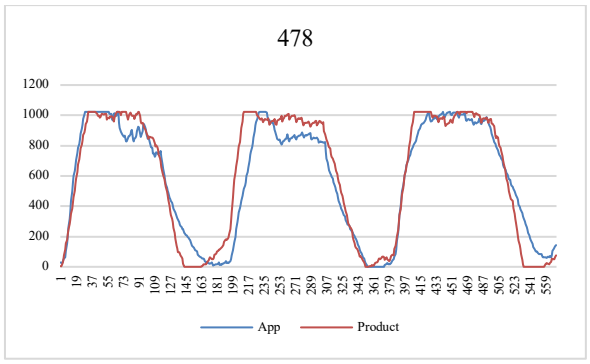

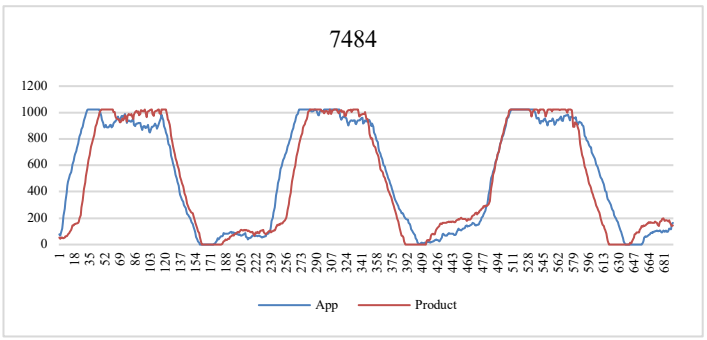

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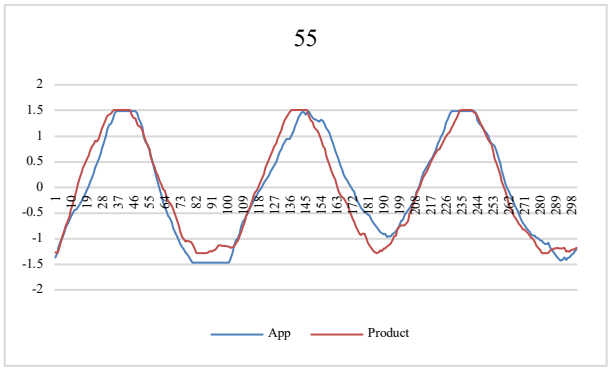

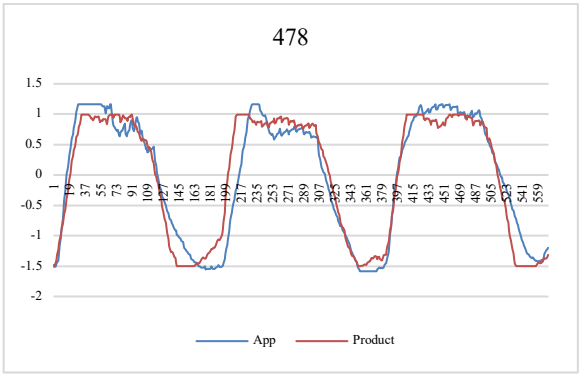

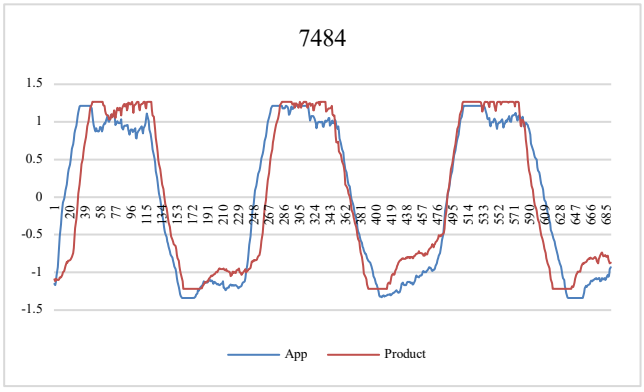

Breath Time: Breathing Exercise product through Physical Volume Change